EFFECT OF RECONSTITUTED METHOD ON SHEAR STRENGTH PROPERTIES OF PEAT

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"Special dedicated with much love and affection to my beloved parents,
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and beloved siblings,
Norhayati, Shaifudin, Noraizam, Azizudin, Nasarudin and Norhashima
Also my booster energy (nieces)
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ABSTRACT

Peat is an organic soil contains more than 75% organic content. Shear strength of the soil is one of the most important parameters in engineering design, especially during the pre-construction and post-construction periods, since used to evaluate the foundation and slope stability of soil. Peat normally known as a soil that has very low shear strength and to determine and understand the shear strength of the peat is difficult in geotechnical engineering because of a few factors such as the origin of the soil, water content, organic matter and the degree of humification. The aim of this study was to determine the effective undrained shear strength properties of reconstituted peat. All the reconstituted peat samples were of the size that passing opening sieve 0.425mm, 1.000mm, 2.360mm and 3.350mm and were pre-consolidated at pressures of 50 kPa, 80 kPa and 100 kPa. The relationship deviator stress- strain, σ_{dmax} and excess pore water pressure, Δu, shows that in both of reconstituted and undisturbed peat gradually increased when confining pressure, σ' and pre- consolidation pressure, σ_c increased. As a conclusion, the undrained shear strength properties result obtained shows that the RS3.350 has higher strength than RS0.425, RS1.000 and RS2.360. However, the entire reconstituted peat sample shows the increment value of the shear strength with the increment of peat size and pre- consolidation pressure. For comparison purposes, the undrained shear strength properties result obtained shows that the reconstituted peat has higher strength than undisturbed peat. The factors that contributed to the higher shear strength properties in this study are segregation of peat size, pre- consolidation pressure, initial void ratio and also the physical properties such as initial water content, fiber content and liquid limit.

ABSTRAK

Gambut adalah tanah organik mengandungi lebih daripada 75% kandungan organik. Kekuatan ricih tanah adalah satu parameter yang paling penting dalam rekabentuk kejuruteraan, terutamanya semasa tempoh pra-pembinaan dan selepas pembinaan, digunakan bagi menilai asas dan cerun kestabilan tanah. Gambut biasanya dikenali sebagai tanah yang mempunyai kekuatan ricih yang sangat rendah dan untuk menentukan dan memahami kekuatan ricih tanah gambut adalah sukar dalam bidang kejuruteraan geoteknikal disebabkan beberapa faktor seperti asal-usul tanah, kandungan air, bahan organik dan tahap penguraian gambut. Tujuan kajian ini adalah untuk menentukan ciri-ciri berkesan kekuatan ricih taktersalir penstrukturan semula gambut. Semua sampel penstrukturan semula gambut melepasi saiz bukaan ayak 0.425mm, 1.000mm, 2.360mm dan 3.350mm dan dikenakan tekanan pra- penyatuan 50 kPa, 80 kPa dan 100 kPa. Hubungan tegasan terikan sisih, σ_{dmax} dan lebihan tekanan air liang, Δu, menunjukkan bahawa kedua- dua tanah penstrukturan semula gambut dan gambut taktergangguu secara beransur-ansur meningkat apabila tekanan terkurung, σ' dan tekanan pra- penyatuan, σ_c meningkat. Kesimpulannya, keputusan ciri- ciri kekuatan ricih taktersalir yang diperolehi menunjukkan bahawa RS3.350 mempunyai kekuatan lebih tinggi daripada RS0.425, RS1.000 dan RS2.360. Walau bagaimanapun, sampel bagi keseluruhan penstrukturan semula gambut menunjukkan nilai kenaikan kekuatan ricih dengan peningkatan saiz tanah gambut dan tekanan pra-penyatuan. Bagi tujuan perbandingan, keputusan ciri- ciri kekuatan ricih taktersalir yang diperolehi menunjukkan bahawa penstrukturan semula gambut mempunyai kekuatan yang lebih tinggi daripada tanah gambut taktergangguu. Faktor-faktor yang menyumbang kepada ciri- ciri kekuatan ricih yang lebih tinggi dalam tesis inin adalah pengasingan saiz gambut, tekanan pra-penyatuan, nisbah lompang asal dan juga ciri-ciri fizikal seperti kandungan air awal, kandungan serat dan had cecair.

TABLE OF CONTENTS

CHAPTER 5 CONCLUSIONS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOL AND ABBREVIATION

ASTM	-	American Society for Testing and Materials
BS	-	Bristish Standard
c	-	Cohesion value of soil
c’	-	Apparent cohesion in term of effective stress
C_c	-	gradation coefficient
C_u	-	uniformity coefficient
Cu	-	Undrained shear strength
CD	-	Consolidated drained test
CU	-	Consolidated undrained test
D_{10}	-	Effective size at 10%
D_{30}	-	Effective size at 30%
D_{60}	-	Effective size at 60%
e_o	-	Void ratio
g	-	gram
Gs	-	Specific gravity
Ha	-	Hectare
HCI	-	Hydrochloric acid
kN/ m^2	-	KiloNewton per meter square
kPa	-	Kilopascal
LL	-	Liquid limit
LOI	-	Loss on Ignition
M	-	Mass
m	-	meter
ml	-	mililitre
mm	-	millimeter
mg/m^3	-	Milligram per cubic meter

O	-	Organic
Pt	-	Peat
PVC	-	Polyvinyl Chloride
RECESS	-	Research Centre for Soft Soils
RS	-	Reconstituted peat
S_u	-	Undrained shear strength
UCS	-	Unconfined Compressive Strength Test
UD	-	Undisturbed peat
USCS	-	Unified Soil Classification System
USDA	-	United States Department of Agriculture
UTHM	-	Universiti Tun Hussein Onn Malaysia
UU	-	Unconsolidated undrained test
μm	-	Micrometer
ε_a	-	Axial strain
σ_{dmax}	-	Maximum deviator stress
w	-	Water content
%	-	Percentage
ϕ	-	Angle of internal friction
ϕ’	-	Angle of internal friction based on effective stress
τ	-	Shear stress
τ_f	-	Shear strength at failure
τ_f’	-	Effective shear strength at failure
Δu	-	Excess pore water pressure
σ_c	-	Pre- consolidation pressure
σ’	-	Normal stress on the failure plane based on effective stress
σ_n	-	Normal stress
μm	-	Micrometer
°	-	Degree
ρk	-	Density of the kerosene (mg/ms)

CHAPTER 1

INTRODUCTION

1.1 Background Study

Peat soil is formed when a decay process of plants is produced and it is divided into three categories namely hemic peat, fibric peat and sapric peat. The difference between peat and inorganic soil leads to difference in the physical and mechanical properties such as high compressibility. During the sampling process and specimen test, the peat soil sample preparation undergoes a careful process. This is because of the structure of fibrous peat has a high compressibility, especially when dealing with low peat decomposition. Physical properties of peat can represent the structure and engineering properties (MacFarlane and Radforth, 1965; and Zainorabidin and Bakar, 2003). Peat is a problematic soil in terms of stability and long term settlement.

Generally, peat soil can be described as soil that is formed by the dead wetland materials that cannot decay in a normal way because of the presence of high water table. When the organic matter decomposed, it turns into a sort of glue called humus, which is strong enough to bind several smaller particles together, making them into larger multi- particles, which can alter the behavior of the soil (Paikowsky *et al*., 2003). Additionally, organic matter also contains products of microbial synthesis which includes (CREAM, 2015):

i. Fresh plant and animal residues (decomposable)
ii. Humus (resistant)
iii. Inert forms of nearly elemental carbon (charcoal, coal or graphite)

Table 1.1 shows the proportionate distribution of peat across the states in Malaysia. There are about 2.5 million hectares of peatland in Malaysia including 0.7 million hectares of peat soil in Peninsular Malaysia, 1.7 million hectares in Sarawak and 0.2 million hectares in Sabah (Wetlands International Malaysia, 2010 and CREAM 2015). The state of Sarawak has the largest areas of peat soils that amounted to 1, 697, 847 hectares, followed by Peninsular Malaysia with 642, 918 hectares; then followed by Sabah which recorded 116, 965 hectares, with the percentage of total peatland area are 69.08%, 26.16% and 4.76% respectively.

Figure 1.1 shows the locations where peat located in Malaysia. The shaded area shows the distribution of peat in Malaysia. Based on Figure 1.1, the largest peatland in Malaysia is located in Sarawak with 16,500 km2. In Peninsular Malaysia, the peat areas are found in the east and west coast areas, especially in the coastal areas of West Johore, Kuantan and Pekan district, Rompin-Endau area, Northwest Selangor and the Perak (Hilir Perak district and Perak Tengah district). In Sarawak, peat occurs mainly between the lower stretches of the poorly drained interior valleys (valley peat) and the main river course (basin peat). Peat is found in the administrative division of Sri Aman, Sibu, Sarikei, Bintulu, Miri, Kuching, Samarahan and Limbang. In Sabah, the organic soils are found around the coastal areas of the Klias peninsula, Krah swamps in Sugut, Kota Belud and Labuk estruaries and Kinabatangan floodplains (Phillips, 1998).

Table 1.1: Proportionate distribution of peat in Malaysia
(Wetlands International Malaysia, 2010; and CREAM, 2015)

Regions	**Total peat area (ha)**	**Percentage of total peatland area (%)**
Peninsular	642, 918	26.16
Sabah	116, 965	4.76
Sarawak	1, 697, 847	69.08
Total (ha)	2, 457, 730	

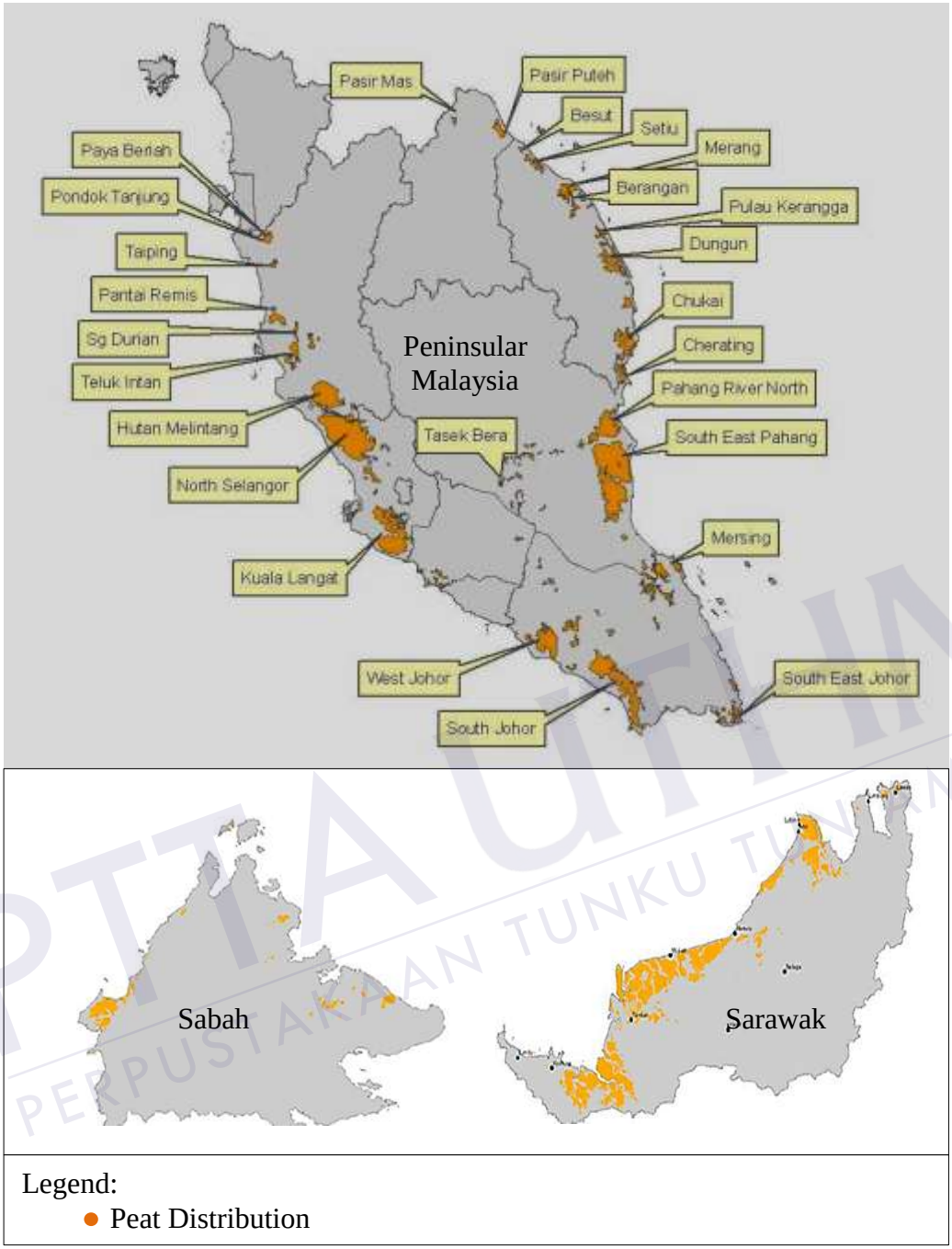

Figure 1.1: Peat Land in Malaysia (Wetlands International-Malaysia, 2010)

Peat soils have higher moisture content and wet density values that are approximately equal to the water density value. Classification of the decomposition proposed by Von Post (1922) was divided into ten groups, H1 to H10. The values represent the degree of decomposition are increasing as the number of classification increase. According to this system, test samples are classified into H3 and H6 with an average organic content of 75% and 30%, respectively. H3 refers to very slightly

decomposed peat, which releases very muddy brown water when being squeezed but no peat passes through the fingers. The remaining plants are still identifiable and no amorphous material is present. H6 refers to moderately decomposed peat with a very indistinct plant structure. When it is squeezed, about one-third of the peat escapes between the fingers and the structure is more distinct compared to before squeezing. The symbol of Peat is 'Pt' and grouped into the soil at the rate of two high organic (organic soil). Based on Mankinen and Gelfer (1982), peat is a soil with organic content greater than 50%, but according to Landva *et al*., (1983); Kearns and Davison (1983); and ASTM D4427 (2013), peat is a soil with organic content more than 75%. Whitlow (2001) and Jelisic and Leppanen (2003) stated that peat has a low bearing capacity in the range 5kPa – 20 kPa which is lower than the soft clay, so the result can cause a slide / collapse (bearing capacity failure) due to low shear strength and high settlement due to high compressibility characteristic of peat. Hence, construction over peat deposit may cause excessive settlement and bearing capacity failure.

1.2 Problem Statement

In construction, there is problem rises on peat soil since it lacks of strength which contributes to ground failure. In order to overcome this problem, ground improvement and alternative methods need to be executed and these certainly gain added costs for development. Nevertheless, the challenge on the peats is the difficulty to collect undisturbed peat samples that truly represent site conditions due to the soil condition and its properties (Munro, 2004). Whitlow (2001) stated that is actually it most impossible to gain a totally undisturbed sample of soft soil because of the process of boring, driving the coring tool, raising and withdrawing the coring tool and extruding the sample from the coring tool which caused some disturbance in the structure of the soft soil. Hence, the knowledge and deeper understanding on forming reconstituted samples and engineering parameters of peat soil is needed to overcome this study.

Peat soil is highly problematic because the traits that originally led to the weak of the soil is due to the low undrained shear strength in normally consolidated state and low bearing capacity under the foundation which cause it is not

recommended in construction by some developers (Gofar and Sutejo, 2007). Construction on peat soil nowadays increasing rapidly because of the lack space on the suitable land. Due to this rapid urban development the land owner and developers are forced to open a new space area. Due to this phenomenon the construction of infrastructure likes building, highway and other construction have to be constructed on the organic soil. There are various construction techniques that have been carried out to support embankments over peat deposits without risking bearing failures but settlement of these embankments remains excessively large and continues for many years. Thus, the active and effective research has to be conducted to find and understand the best solution on this phenomenon to overcome this problem.

Generally, peat commonly occur as extremely soft, wet, unconsolidated surficial deposits that are an integral part of wetland systems. These types of soils contribute to geotechnical problems in the area of sampling, settlement, stability, in situ testing, stabilization and construction. Formation of peat significantly takes time to fully decompose. It will decompose from fibrous (least decomposed) to hemic (intermediate decomposed) and then settle down as sapric (most decomposed). The degree of peat decomposition will contribute to the changing of peat fiber, thus it affects to the changing of engineering properties such as shear strength properties. The different sizing of peat fiber will result in different shear strength properties. Hebib (2001) has revealed that least decomposed peat has higher shear strength rather than most decomposed peat due to the presence of large fiber in the peat acts as reinforcement.

Peat also contains high water content because of the high presence of hollow pore in the fiber itself. Due to this condition, it may affect the strength of the peat. To remove the water content from peat soil, the pre- consolidation slurry method is suitable to be applied in this study. Pre- consolidation slurry method is a very popular method to drain out the excessive water content from the soil specimen. This method is popular conducted by researchers to form the reconstituted samples from slurry samples. Barnes (2015), Anggraini (2006) and Rabbee *et al.*, (2012) has figured that the reconstitution specimen is one of the great techniques in the laboratory to obtain element testing of repeatable and homogenous test samples. Anggraini (2006) conducted reconstituted sample on fibrous peat at Pontian Johor. The peat sample was consolidated with pre- consolidation pressure (50kPa, 100kPa, 150kPa and 200kPa) to test the sample on the triaxial Unconsolidated Undrained

Triaxial Test (UU- Test). The result of shear strength properties (cohesion and angle of friction) of reconstituted peat increased, due to the increase of the pre-consolidation pressure. Differ from this thesis, the author conducted the reconstituted peat on Parit Nipah peat that classified as hemic peat. The reconstituted peat sample through segregation peat size via wet sieving and consolidated with the 50kPa, 80kPa and 100kPa pre- consolidation pressure to test the specimen on the Consolidated Undrained Triaxial Test (CU- Test).

1.3 Research Objectives

The aim of this study was to determine the effective undrained shear strength properties of reconstituted peat. Therefore, the shear strength properties (c' and ϕ') need to investigate to correlate with the effect of the reconstituted method (peat size and pre- consolidation pressure). To achieve the outcomes, the objective was highlighted

The specific objectives of this thesis are:

1) To determine the physical properties of undisturbed and reconstituted peat.
2) To investigate the shear strength parameters of undisturbed and reconstituted peat of different sizes of peat and in different pre- consolidation pressure.
3) To correlate the shear strength properties with the effect of passing peat size and pre- consolidation pressure.

1.4 Scope of Research

The scope of this study is about to investigate the shear strength properties of reconstituted peat sample. Peat samples are obtained from Parit Nipah, Johor. The samples were taken at depth of about 0.3m – 1.0m (depends on the existing of ground water table) from surface level. The samples were divided into two samples that are disturbed sample and undisturbed sample. The disturbed peat samples were obtained to reconstruct peat as reconstituted peat sample meanwhile; undisturbed peat samples were obtained in this study as a comparison sample with reconstituted peat samples. The physical properties test was also performed in this study such as moisture content, liquid limit, organic content, fiber content and specific gravity. All

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